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HIGH HARDNESS SINTERED COMPACT FOR MACHINE TOOLS AND ITS PRODUCTION METHOD

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(54) Name of Invention: High Hardness Sintered Compact for Machine Tools and Its Production Method

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Specification

1. Name of Invention

High Hardness Sintered Compact for Machine Tools and Its Production Method

2. Scope of Claim

(1) High hardness sintered compacts for machine tools comprised of a high hardness sintered compact 2 mm or less in thickness, consisting only of a high pressure phase boron nitride layer and a ceramic layer, attached to a base material of sintered hard alloy and characterized by the fact that the layer of sintered hard alloy

base material 0.5 mm or less in thickness that is in contact with the high hardness sintered compact contains more iron group metals than other parts of said sintered hard alloy base material.

(2) A method of producing high hardness sintered compacts for machine tools characterized by the placement, on at least one surface of a sintered hard alloy base material, of a raw powder for sintered hard alloy as is, in a shaped form, or a half sintered form, the placement thereon of a raw powder for high hardness sintered compact consisting of high pressure phase boron nitride and ceramic as is or in a shaped form, the hot pressing of the metal mass under high pressure and high temperature to sinter and bond at the same time.

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3. Detailed Description of Invention

There are very high expectations for the sintered compacts of high pressure phase boron nitride, particularly cubic boron nitride (hereinafter referred to as CBN), as a future material for machine tools. Although CBN sintered compacts where some CBN crystals are bonded with Co alloys are currently out on the market for use in cutting machine tools, metal bonding, as expected, does not allow for sufficiently satisfactory performance. Based on this perspective, the inventors devoted themselves to the study of ceramics bonded CBN sintered compacts and proposed CBN sintered compacts with superbly outstanding cutting performance.

Subsequently, its structure as a machine tool was studied in order to use it as a cutting machine tool. It was immediately concluded that it would suffice to have the CBN sintered compact in a thickness just enough to function as a blade, since CBN is expensive. It was concluded that a thickness of 2 mm is sufficient, and that the most desirable thickness would be between 1.5 mm and 0.5 mm. The qualities of the base material were then considered. This subject was studies from a wider perspective, there also being the view that the base material can be anything. However, it was concluded that sintered hard alloys are the most desirable in terms of stiffness and fatigue strength. Of the sintered hard alloys, it was concluded that those of the WC group are the most desirable due to

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their superiority and stiffness, fatigue strength, and thermal conductivity.

This conclusion coincides with the structure of the aforementioned Co alloy bonded CBN sintered compact for cutting machine tools.

In the case of this invention, ceramic, particularly such nitrides, carbonitrides, and carbides of the 4a family as TiN, Ti, and (C,N) are used to bond CBN crystals. Since CBN, compared to these ceramics, has a lower thermal expansion coefficient than such metals as Co as shown in Figure 1, it is necessary to use sintered

hard alloys with low metal content to minimize such post-hot pressing phenomena caused by thermal stress as thermal cracks and residual thermal stress. (See Figure 1) A phenomenon that resulting from the use sintered hard alloys with low metal content that posed a problem is the weakening of the bond between the CBN sintered compact and the base material. As expected, the bond strength is dependent to a large extent on the presence of such metals as Co.

As a measure being considered to counter this problem is to place a thin metal film between the base material and the CBN sintered compact when hot

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pressing. The present inventors initially attempted this as well and achieved

sufficient bond strength. However, when this structure was tested in actual machine tools, it was found that the structure comes apart at this soft intermediate layer. Because the life of machine tools made of CBN sintered compact is surprisingly long, said layer is also repeatedly exposed to stress in significantly large numbers. Because fatigue progresses notably when the yield limit is exceeded, a possible measure to counter this naturally is to increase the yield strength. The present inventors conceived an extremely simple idea of increasing the metal content of the sintered hard alloy only in areas close to the bonding surface. If

the thickness of the layer with a high metal content is 0.5 mm or less, or preferably 0.2 mm or less, the thick base material will outweigh the problem of thermal stress can be ignored as a contributing factor and the latter can be ignored.

As a method of achieving this end, it is possible to form an extremely thin, for example of a thickness of 50 micron, layer of high Co content by placing, for example, a small amount of a fine powder mixture of WC containing 20% Co on a base material of WC with 7% Co.

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In the case of WC-Co at the sintering temperature in a vacuum or a hydrogen atmosphere of 1 atmosphere, liquid Co easily shifts by a few mm or more, making it difficult to maintain the difference in Co concentration. However, the movement of liquid Co is extremely small under extreme pressure that it can be said there is virtually no movement. As regards methods of uniformly placing a thin layer of the fine powder mixture on the base material, mixing the powder into a solvent, such as toluene, containing ethyl cellulose, as a bond to form a paste, and applying said paste with a brush is an example of a simple method of achieving this. When forming a layer 1 mm or more in thickness, a shaped mixture, a half sintered mixture sliced into the desired thickness and shaped, or a sintered compact of the desired thickness can also be used. Forming thin plates of about this thickness can be accomplished

easily with the modern sintered hard alloy technology.

The structure of sintered compacts pertaining to this invention is as shown in Figure 2. 1 is the layer of high hardness sintered compact, 2 mm or less in thickness, formed by bonding CBN with ceramic, and 2 is the layer of sintered hard alloy 0.5 mm or less in thickness containing more iron group metal than the sintered hard alloy base material depicted by 3.

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Although WC-Co compositions were used in the example above, TiC or TaC can also be included in the compositions. Using such other iron group metals as Ni in the place of Co does not negate the effect and may even be more preferable in some cases. Furthermore, sintered hard alloys of the TiC family may also be used. Although the stiffness and thermal conductivity of this family is significantly lower than those of the WC family, it is still more preferable than such metals as copper. Following are some working examples.

Working Example 1

CBN powder with an average particle size of 7 μ and TiN 0.92 powder with an average particle size of 1 μ were mixed well in a mortar at a ratio of 60% to 40% by volume. 2% of camphor was added to this mixture, which was then pressed and shaped into a circle with an external diameter of 10mm and a height of 1.5 mm.

Separately from the foregoing, a circular plate with an external diameter of 10 mm and a height of 3 mm was made of WC-7% Co sintered hard alloy. Further, a WC-20% Co powder mixture was added to toluene containing 20% dissolved ethyl cellulose by volume to form a paste. The paste was applied on the aforementioned circular sintered hard alloy plate in uniform thickness. The pressed and shaped

circle consisting of CBN and TiN that was prepared earlier was placed on the side

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of the circular sintered hard alloy plate with the paste, and the whole thing was inserted into a stainless container. The container was heated in a vacuum furnace with a vacuum of 10^{-4} mm Hg at 1100°C for 20 minutes, and then degassed. It was placed in a girdle-type extreme pressure device. Pyro ferrite was used as the pressure medium and a graphite cylinder was used as the heater. The space between the graphite filter and the sample was filled with NaCl. The pressure was first increased to 55 Hb, the temperature was subsequently raised to and maintained at 1300°C for 30 minutes, after which the temperature was lowered and the pressure was gradually decreased. The sintered compact thus obtained was comprised of hard sintered compact about 1 mm in thickness containing CBN, a WC-20% Co layer of about 0.1 mm, and further a WC-7% Co layer 3 mm in thickness which were all bonded together

firmly. For the purpose of comparison, a pressed and shaped circle comprised of CBN and TiN was placed directly on a circular sintered hard alloy plate of WC-7% Co without applying the WC-20% Co powder on the latter, and prepared a sintered compact under the same conditions. Also in this case, the hard sintered compact layer and the sintered hard alloy were bonded.

The two types of sintered compacts were cut using a diamond blade, prepared

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a tool by soldering a 12.7 mm square of CIS Standard SNGN 4.33 M on to one side of the sintered hard alloy chip 4.76 mm in thickness, and performed cutting tests using a frontal milling machine. FC_{25} cast iron 80 mm in width and 300 mm in length was cut length wise. The cutting rate, incision, and table rate were 500 m / min, 1 mm, and 2,800 mm / min, respectively, and a water soluble cutting oil was used. The chip pertaining to this invention with a WC-20% Co layer, 0.1 mm in thickness and containing more Co than the base material, between the base material of WC-7% Co alloy and the hard layer containing CBN performed 500 passes and reached the end of its useful ness with normal wear. As opposed to this, the chip formed by bonding the hard layer containing CBN directly to the WC-7% Co base material fell apart at the interface between the two after 200 passes.

Working Example 2

CBN powder with an average particle size of 4 μ and $Ti(C_{0.5}N_{0.4})_{0.80}$ powder with an average particle size of 1 μ were mixed at a ratio of 70% to 30% by volume. A pressed and shaped solid was formed from the mixed powder and a circular sintered hard alloy plate of WC-10% Co to serve as the based material was prepared thereafter in accordance with the procedures described in Working Example 1. A

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pseudo sintered compact of WC-25% Co sliced to a thickness of 0.3 mm and shaped was placed between the pressed and shaped solid made of the mixed powder containing CBN and the base material and sintered under the same conditions as in Working Example 1. Cutting the sintered compact thus obtained revealed that it was a compound body consisting of a base material of WC-10% Co alloy with a 0.2 mm WC-20% Co layer on top, and a layer of hard sintered compact comprised of CBN and Ti(C.N) bonded to the layer.

Working Example 3

CBN powder with an average particle size of 1 μ and $ZrN_{0.89}$ powder with an average particle size of 1 μ were mixed at a ratio of 50% to 50% by volume. A circular plate of WC-12% Co with an external diameter of 10mm and a thickness of 3 mm was placed in a Mo container, a circular plate of WC-20% Co with an external

diameter of 10 mm and a thickness of 0.5 mm was placed on opt, and the container was filled with CBN and ZrN powder. This was then sintered in the same manner as in Working Example 1 at 55 Hb and 1350°C for 30 minutes. An observation of the cut surface of the sintered compact revealed a hard sintered compact comprised of CBN and ZrN and the base material of WC-12% Co sintered hard alloy sandwiching a WC-20% Co layer 0.5 mm in thickness, all of which were all bonded closely together.

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4. Brief Description of Drawings

Figure 1 is a graph designed to explain the contents of this invention and show the thermal expansion coefficients of CBN, WC-5% Co, WC-15% Co, and Co metal at various temperatures.

Figure 2 shows the structure of this sintered compact pertaining to this invention. 1 is the hard sintered compact comprised of CBN and ceramic, and sintered hard alloy base material 2 is bonded to it via 2. 2 is an intermediate layer of sintered hard alloy containing more iron group metal than base material 3.

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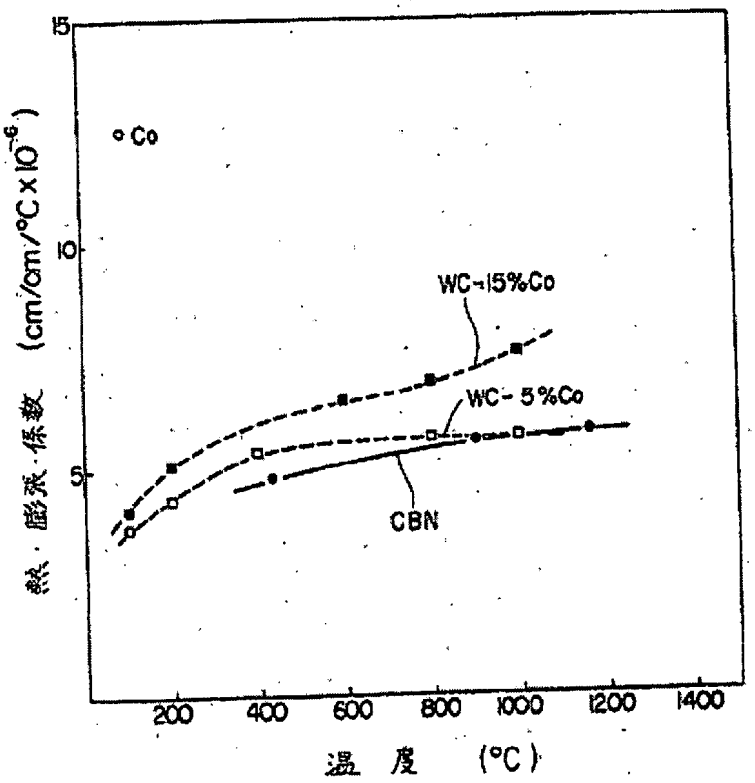
Figure 1



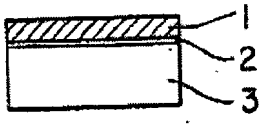
Vertical

Temperature

Horizontal

Thermal Expansion Coefficient

Figure 2



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Amendment of Proceedings

January 25, 1983

To: Mr. Zenji Kumagaya

Commissioner, Patent Office

1. Indication of Case

~~Application for Utility Model Utility Model~~ Patent Application Number 50112 of 1977

2. Name of Invention

High Hardness Sintered Compact for Tools and Its Production Method

3. Amending Party

Relationship to Case: Applicant

Full Name (Name): (213) Sumitomo Electric Industries Corporation

5. Date of Order for Amendment

~~YY / MM / DD~~

Voluntary Amendment

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6. Object of Amendment

Detailed explanations in Specification.

8. Contents of Amendment

(1) Lines 6 through 7 on page 8 of Specification

Correct "Ti, (C.N)" to read "Ti(C.N)"

(2) Insert the following after line 7 on page 6 of Specification:

"Although the foregoing pertains to high pressure phase boron nitride sintered compact containing CBN, the same also applies to sintered compact containing wurtzite form boron nitride."

(3) Insert the following after the first line on page 10 of Specification:

"Working Example 4

Instead of the BN powder used in Working Example 3, wurtzite form boron nitride powder elaborated by the shock-wave technique was used and the procedures of Working Example 3 were otherwise followed to obtain a sintered compact. An observation of the cut surface of the sintered compact revealed a hard sintered compact comprised of wurtzite form BN and ZrN and the base material of WC-12% Co sintered hard alloy sandwiching a WC-20% Co layer 0.5 mm in thickness, all of which were all bonded closely /3 together.